FROM BRUSH

TO ANTATION

AN ECONOMIC AND SILVICULTURAL STUDY

ST VIRGINIA UNIVERSITY AGRICULTURAL EXPERIMENT STATION

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COVER PHOTOGRAPHS

Top—A typical brush-covered old field consisting primarily of hawthorn, crab apple, sassafras, and black locust. Such mixtures arise where old pastureland was abandoned and no desirable seed source was present nearby.

Bottom—The same area as above, four years after bulldozing and planting with conifers. On the drier slopes no additional brush control is needed, and the pines grow rapidly. Pitch pine is shown in the foreground, and white pine at the extreme right.

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Introduction

ABANDONED fields, formerly used for agriculture or pasture, are scattered abundantly throughout the West Virginia countryside. Some of these have reseeded naturally with softwoods and hardwoods of high commercial value; others now support young plantations of pine, spruce, yellow-poplar, or black locust; however, thousands of acres of old fields have reverted to brush and worthless tree species, and will produce no salable forest products for many decades.

Unproductive stands originate wherever desirable seed sources are unavailable. Eventually, bird-disseminated species become established on these sites. Hawthorn (*Crataegus* spp.), blackgum (*Nyssa sylvatica* Marsh), sassafras (*Sassafras albidum* [Nutt.] Nees), crab apple (*Malus coronaria* [L.] Mill.), black locust (*Robinia pseudoacacia* L.), and sumac (*Rhus* spp.) form the typical cover. Inadequate stocking and poor distribution of seedlings result in wide, spreading crowns, thus further delaying the subsequent establishment of more desirable species. Many of these low-value hardwoods occupy soils of high potential value for forest production. Wherever old stumps occur, the quality of these sites can be ascertained by examining growth rings.

In 1954 the West Virginia University Agricultural Experiment Station began a study to determine the most economical method of converting these stands to productive forests. This bulletin summarizes the results obtained in converting 31 half-acre plots.[1]

The area selected for this study is located in the Division of Forestry Farm Woods in Monongalia County, West Virginia. This land, abandoned approximately 25 years ago, is typical of thousands of acres in West Virginia. Dense thickets of bird-disseminated species completely covered this area. Although a few trees were cut for fence posts in 1953, the majority have no potential value for wood products.

[1]A preliminary summary of this experiment was published in October 1957. See West Virginia University Agricultural Experiment Station Bulletin 408, *Convert Unproductive Hardwood Stands to Desirable Forest Types.*

Procedure

In converting these stands, existing woody growth must be permanently removed. This can be accomplished through bulldozing, poisoning, or cutting. The most advantageous control method is that which adequately clears the site at the lowest cost.

After clearing, the new forest crop must be established immediately to avoid future brush competition and expensive cleaning operations. Natural regeneration can be used in those stands where sufficient desirable tree seed is present. Unfortunately, most of these areas contain no desirable natural seed source, and planting is a necessity.

Eight brush-control measures were tested during the five-year period covered by this study. These included bulldozing, basal spraying, cupping and poisoning, frilling and poisoning, combination basal spraying and poisoning, frilling and poisoning, combination basal spraying and frilling, cutting with a mechanical brush cutter, foliage spraying, and cutting by hand. The treatments are described briefly.

BULLDOZER

An International TD-9 or TD-14 *bulldozer* was found satisfactory for uprooting woody growth from future planting areas. Scattered stems larger than 6 inches d.b.h. (diameter breast high) were left, and later frilled and poisoned, since such stems require excessive time to bulldoze out. The bulldozer and operator were supplied by the Soil Conservation Service at the rate of $8.50 per hour. In site preparation work it is essential to set the blade of the dozer exactly at ground level. In this position the blade cuts deeply enough to uproot and dislodge even the smallest trees and brush, but disturbs only a minimum amount of litter and top soil. Uprooted brush can be left in piles scattered throughout the area, or stacked in windrows along the sides. Brush piles within the planting area should be burned since they cover a considerable area which could otherwise be planted. When brush is pushed to the sides, the major portion of the site is cleared. These windrows can be left to rot.

BASAL SPRAYING

In *basal spraying* or bark spraying the tree is not cut. The bark at the base of the tree is completely saturated with herbicide to a height of 18 inches. Spray is applied until the bark is saturated and additional application merely runs off. All herbicides are most effective when applied in the spring, immediately after the foliage develops, and become progressively less effective if applied later in the season. A 5 per cent solution of 2, 4, 5-T (low volatile ester of 2, 4, 5-trichlorophenoxyacetic acid) in a petroleum carrier is most effective for basal spraying.

CUPPING

In *cupping,* notches are chopped at regular intervals around the bole. The cups are approximately 6 inches wide, with 4-inch intervals between adjacent cups. Notches may be cut at a convenient chopping height or at the base of the trunk. When located near the roots, they afford greater penetration of chemical into the root system; thus a higher mortality is obtained.

FRILLING

A *frill* consists of a single line of overlapping downward axe cuts made completely around the bole. Frills are customarily made at a convenient chopping height, approximately 4 feet above ground. Immediately after frilling, a chemical is poured or sprayed into the cut until the exposed wood surface is thoroughly wetted. A 4-pound-per-gallon water solution of Ammate or a 4 per cent mixture of 2, 4, 5-T in a water carrier are effective herbicides to use in frills.

COMBINATION OF BASAL SPRAYING AND FRILLING

A *combination of basal spraying and frilling* is often more economical than either method alone. Trees larger than 3.5 inches d.b.h. are frilled and treated with a 4 per cent mixture of 2, 4, 5-T in a water carrier. Smaller trees should be sprayed with a 5 per cent solution of 2, 4, 5-T in a petroleum solvent.

FOLIAGE SPRAY

A *foliage spray,* 0.5 per cent mixture of 2, 4, 5-T in a water carrier, was applied to the leaf surface in the late spring. One month later a second spraying was made, applying additional chemical to hard-to-kill species and areas apparently missed in the first spraying. Often a third spraying was needed to eliminate scattered sprouts and root suckers of sassafras and black locust.

BRUSH CUTTER

A portable power-driven *brush cutter* with a circular blade was used to clear brush in some areas. The blade was held close to the ground in order to cut the brush off as low as possible. It was necessary to cup and poison trees over 2.5 inches d.b.h., since a brush cutter takes excessive time on trees larger than this.

For the purpose of comparison, one area was *cleared by hand* using brush hooks and axes. The debris was piled and burned before planting.

Planting

In the spring, immediately after hardwood control had been completed, each half-acre treatment area was divided into two quarter-acre sections. Sections located on the lower portion of the slope were planted with white ash (*Fraxinus americana* L.) or yellow-poplar (*Liriodendron tulipifera* L.). Those on upper slopes were planted with white pine (*Pinus strobus* L.), and shortleaf pine (*Pinus echinata* Mil.) or pitch pine (*Pinus rigida* Mil.). Whenever possible 6 by 6-foot spacing was used. This permitted the planting of approximately 1,210 seedlings per acre, or 303 seedlings per section. However, this number varied from one treatment area to the next because of interference from standing woody growth and other obstacles. Hand planting was used on all areas.

One year after planting, survival counts were made on each area to determine which species had the highest survival following each hardwood control measure (see Table 4). Survival on areas converted in 1954, 1955, and 1956 was rechecked in 1959. Survival figures for each species and hardwood control costs were used together to determine the most suitable method of stand conversion.

Evaluation of Brush-Control Methods

The costs for converting each area were analyzed in 1959, five years after this study was initiated. Table 1 gives a summary of these data. From these data, estimates of costs for converting partially brush-covered areas were also obtained by reducing brush-control costs for completely brush-covered lands by the amount of open area (see Tables 2 and 3).

Table 1. Average Cost Per Acre for Converting Completely Brush-covered Land by Each of the Brush-control Methods*

Hardwood Control Method	(A) Initial Brush-Control Costs	(B) Planting Labor	(C) Additional Brush-Control (Cleanings)	(D) Total Conversion Costs	
				Pine	Hardwood
Bulldozing	$55.57	$19.00	$ 4.00	$ 93.09	$89.46
Basal Spray	40.96	29.00	4.00	88.48	84.85
Basal Spray and Frill	45.43	23.71	4.00	87.66	84.03
Frilling	50.69	39.00	8.00	112.21	108.58
Cupping	42.13	27.50	8.00	92.15	88.52
Cut-off Saw	18.05	21.00	22.00	75.57	71.94
Foliage Spray	21.00	16.00	8.00	59.52	55.89
Hand Clearing	79.50	20.00	32.00	146.02	142.39

*The total conversion cost was obtained by adding the cost of the planting stock and planting costs to the costs of controlling the brush. The cost of 1,210 hardwood seedlings, $10.89; the cost of 1,210 pine seedlings, $14.52. Labor costs computed at $1.00 per hour.

TABLE 2. AVERAGE COST PER ACRE FOR CONVERTING PARTIALLY BRUSH-COVERED AND COMPLETELY BRUSH-COVERED LAND TO PINE (INCLUDING SEEDLING AND PLANTING COSTS)

HARDWOOD CONTROL METHOD	PORTION OF AREA COVERED WITH BRUSH					
	ENTIRE	3/4	2/3	1/2	1/3	1/4
Bulldozing	$93.09	$78.20	$73.23	$63.31	$53.38	$48.41
Basal Spray	88.48	77.24	73.49	66.00	58.51	54.76
Basal Spray and Frill	87.66	75.30	71.18	62.95	54.71	50.59
Frilling	112.21	97.54	92.65	82.86	73.08	68.19
Cupping	92.15	79.62	75.44	67.09	58.73	54.55
Cut-off Saw	75.57	65.55	62.22	55.55	48.87	45.53
Foliage Spray	59.52	52.27	49.85	45.02	40.19	37.77
Hand Clearing	146.02	118.15	108.85	90.27	71.69	62.40

TABLE 3. AVERAGE COST PER ACRE FOR CONVERTING PARTIALLY BRUSH-COVERED AND COMPLETELY BRUSH-COVERED LAND TO HARDWOODS (INCLUDING SEEDLING AND PLANTING COSTS)

HARDWOOD CONTROL METHOD	PORTION OF AREA COVERED WITH BRUSH					
	ENTIRE	3/4	2/3	1/2	1/3	1/4
Bulldozing	$89.46	$74.57	$69.60	$59.68	$49.75	$44.78
Basal Spray	84.85	73.61	69.86	62.37	54.88	51.13
Basal Spray and Frill	84.03	71.67	67.55	59.32	51.08	46.96
Frilling	108.58	93.91	89.02	79.23	69.45	64.56
Cupping	88.52	75.99	71.81	63.46	55.10	50.92
Cut-off Saw	71.94	61.92	58.59	51.92	45.24	41.90
Foliage Spray	55.89	48.64	46.22	41.39	36.56	34.14
Hand Clearing	142.39	114.52	105.22	86.64	68.06	58.77

TABLE 4. AVERAGE PER CENT SURVIVAL IN PLANTATIONS ONE YEAR AFTER PLANTING

BRUSH-CONTROL METHOD	SPECIES				
	WHITE PINE	PITCH PINE	SHORTLEAF PINE	YELLOW-POPLAR	WHITE ASH
			Percent		
Bulldozing	84.5	93.1	81.2	67.4	69.9
Basal Spray	68.1	78.1	70.7	64.1	68.7
Basal Spray and Frill	77.3	——	74.9	70.5	58.8
Frilling	45.0	77.1	——	93.9	75.9
Cupping	87.7	82.8	——	87.0	80.4
Cut-off Saw	93.6	——	80.3	48.0	00.0
Foliage Spray	63.4	——	——	45.8	——
Hand Clearing	64.1	——	——	66.9	——

The costs of planting stock and planting labor were not reduced since these costs would remain approximately the same regardless of the amount of brush originally occupying the site.

Planting costs varied greatly, depending on the method of hardwood control employed. Those methods which opened up the site most com-

pletely facilitated hand planting and generally resulted in the lowest planting costs per acre. Hardwood brush that was controlled with chemicals remained on the planting area. This created a major inconvenience for planting crews and noticeably increased planting costs.

When Ammate and the hormone poisons (2, 4, 5-T and related compounds) are used on woody vegetation, a period of six months to two years is required for the poisons to become effective. For this reason it is often necessary to delay evaluation of poisoning results for a year or more to obtain reliable data on mortality percentages. This gradual opening-up of the crown canopy following poisoning is actually advantageous where hardwood seedlings are planted, since most hardwoods require partial shade during their first few years. However, this cover is extremely detrimental to pine because pines require a great deal of light during their seedling stage.

Bulldozing. This method appears to have given the most effective brush control. On middle- and upper-third slope positions, even five years after bulldozing, there was no indication that additional hardwood control would be needed to assure future survival of planting stock. In the bottoms and on lower-third slopes, where the soils are more fertile, black locust and sassafras sprouts were abundant and grew rapidly. However, hardwoods were planted on these better sites, and the partial shade cast by sprouts appears to be beneficial to neighboring yellow-poplar and white ash seedlings, resulting in better height growth and increased vigor. On this basis, the present plan is to leave these scattered sprouts until it is apparent that their shade is no longer beneficial.

Contrary to expectations, no erosion problem was present on dozed areas, even though these sites had slopes up to 30 degrees. The season in which bulldozing is done is very important insofar as erosion is concerned. For example, areas dozed in the late winter and early spring are invaded quickly by rank herbaceous plants, including goldenrod (*Solidago* spp.), asters (*Aster* spp.), wild lettuce (*Lactuca* spp.), and other composites. If these areas had been dozed in the late summer, fall, or winter, however, it is likely that heavy erosion from winter rains and thaws would have occurred. The shade from herbaceous annuals appears to have had no detrimental effect on the pine and hardwood seedlings, and their roots held the soil. By the second year the dense grass sod, which had developed over the entire area, crowded out the annuals and completely occupied the site. Grass sod has offered minor competition to pines. Pine survival has been excellent on dozed areas, and pine height growth has been better on such areas than on all other treatment areas. This high growing rate is attributed to the greater amount of light provided by bulldozing and the high light requirements of pine seedlings.

Growth of white ash and yellow-poplar has been severely curtailed wherever heavy competition from grass sod was present. Experiments are now underway to find methods of eliminating grass competition around hardwood seedlings through spot spraying with selective grass herbicides. Hardwood survival on bulldozed areas has been fair, but growth has been poorer than on plots where some overhead shade has been afforded by standing hardwood brush. This is probably due to the greater amount of light entering the site following bulldozing and the tolerance rating of hardwood seedlings.

Basal Spraying. This method gives effective brush control, but a great deal of additional hardwood control work is needed if the area is to be planted with pine, since sprouts from partially-killed root systems offer too much shade for the intolerant conifers. Hardwood seedlings in these areas have grown rapidly and are better in height growth and vigor than hardwood seedlings in bulldozed areas.

Although annuals invaded the forest floor following basal spraying, their density is low compared to bulldozed areas, and offers no serious opposition to seedling survival and growth. No grass sod has developed because of the partial shade afforded by the standing hardwood brush.

Frilling and Poisoning. Frilling and poisoning alone proved inadequate as a brush-control method because many stems were too small to treat by frilling, and these began to grow rapidly when the larger stems had been poisoned. Although pine and hardwood survival was high, it was obvious that repeated brush control would be necessary if planted seedlings were to be brought through successfully.

Basal Spraying and Frilling. These two treatments used together proved the most effective of the poisoning methods employed. Frilling gave somewhat less expensive but effective control of trees larger than 3.5 inches d.b.h., and basal spraying gave effective control of smaller woody growth. Pines have not grown as well due to excessive shade from the dying overhead woody growth.

Cupping and Poisoning. Notches with Ammate proved expensive and inadequate for brush control. Trees 2 to 3 inches in d.b.h. were too small to cup; these were cut off 6 inches above the ground and a tablespoonful of Ammate crystals was placed on each stump. Stems smaller than 2 inches d.b.h. were cut and painted with a 1-pound-per-gallon solution of Ammate in water. Many trees were partially alive five years after cupping, and gave indication they would continue to live for many years. Stumps treated with Ammate crystals frequently sprouted and these stems interfered with the development of the planted pine seedlings. Height growth of hardwood seedlings on these plots has been good, but that of pine has been extremely poor.

Cut-off Saw. Although the brush cutter proved the least expensive of all brush-control methods, vigorous sprouting from cut stems has invariably followed. Sprouts competed with both planted hardwoods and pines and have been a costly nuisance. Cleanings at two-year intervals have been required to maintain the vigor of the pine seedlings. Where stems are cut at ground level and mowing has been used annually for Christmas tree production, these sprouts are kept under control and eventually are crowded out by the grass sod.

Foliage Spraying. Foliage sprays were used successfully where brush was 10 feet or less in height. Although this is an economical method of attacking brush, it is evident that two or even three sprayings are needed where the brush cover is dense or where species which produce root suckers (particularly sassafras and black locust) are present. Even when three sprayings are used, some release work is needed the third year after planting. Where foliage-sprayed areas are mowed regularly for Christmas tree production, sprouts are kept down and additional cleaning work is rarely needed.

Hand Clearing. The cost of clearing brush-covered lands by hand is far greater than that of controlling brush by bulldozing, spraying, or mechanical brush cutting. In addition, sprouting on these areas is so vigorous that it is always necessary to clean or mow annually until crown closure takes place.

In areas that were treated with chemicals, falling branches and tops from dying trees resulted in breaking of both pine and hardwood seedlings. Although this damage, at first glance, appears to be widespread, counts over a five-year period show that a maximum of 5 per cent of the seedlings are damaged in this way. Many of these stems give no evidence of permanent defect from this injury.

Thus, in preparing sites for coniferous plantations, bulldozing, foliage spraying, and the brush-cutting saw all proved satisfactory; however, the brush cutter and foliage spraying required cleanings, if the pine was to be brought through successfully. Where Christmas tree production is the objective and regular mowings are contemplated, hand cleaning is not needed. Observations show that foliage sprays are most effective where brush is less than 10 feet in height; the brush cutter is satisfactory where few trees exceed 20 feet in height or 2.5 inches in diameter; and the bulldozer is necessary where large vegetation is encountered.

Where hardwoods are to be planted, chemicals give the most satisfactory brush control. Although basal spraying is effective, a combination of basal spraying and frilling is slightly less expensive. Since

death occurs gradually over a period of two years or more, the planted hardwoods benefit from the gradual exposure as the crown canopy slowly opens up.

Economic Considerations

Because of the high cost of hardwood control and planting, determined through this study, it appears economically impractical to convert brush-covered lands solely for general forestry purposes, even when pulpwood can be harvested periodically throughout the rotation. Stand conversion costs vary considerably with the hardwood control method employed, but all are far in excess of those feasible for producing pulpwood and sawlogs.

When products other than pulpwood and sawlogs are to be produced, the capital needed for brush control and seedling establishment can be a sound investment. Production of Christmas trees or ornamentals involves a rapid turnover of invested funds. Since interest on costs will be compounded over a much shorter period, a greater initial expenditure is allowable. Furthermore, Christmas trees or ornamentals may be harvested in conjunction with the first pulpwood and sawlog rotation, thus providing the necessary early income to offset high site preparation and planting costs.

In this presentation three distinct alternatives are analyzed to show comparative rates of interest. Although the returns from each are widely divergent, motives other than profit alone will often determine the procedure to be followed. The three analyses are:

Case 1. Where only pine pulpwood and sawlogs are to be harvested.

Case 2. Where Christmas trees as well as pulpwood and sawlogs are produced during the first rotation. Later rotations are for pulpwood and sawlogs alone.

Case 3. Where Christmas trees are the sole objective.

These analyses have been made on the premise that continuous production is anticipated. With the exception of Case 3, it is presumed that later rotations will be obtained through natural regeneration methods. The original plantation will be planted with white or red pine at a 6 by 6-foot spacing (1,210 trees per acre). Of these, 847 trees, or 70 per cent, will survive. These analyses are based on standard discount procedures.

Case 1. Pulpwood and sawlog production. The incomes and returns from continuous production of pine on 70-year rotations are as follows:

Conditions

Area ..... One acre
Crop production period ..... Repeated production on a 70-year rotation

Costs

Cleaning at age 6 .....$ 22.00
Taxes, protection and administration 0.50/year

Returns

Thinning, age 30 (6 cords pulpwood @ $2/cord) 12.00
Thinning, age 40 (6 cords pulpwood @ $2/cord) 12.00
Thinning, age 55 (4 cords pulpwood @ $2/cord and 3,000 bd. ft. sawlogs @ $18/M) 62.00
Harvest cutting, age 70 (12,000 bd. ft. sawlogs @ $18/M) $216.00

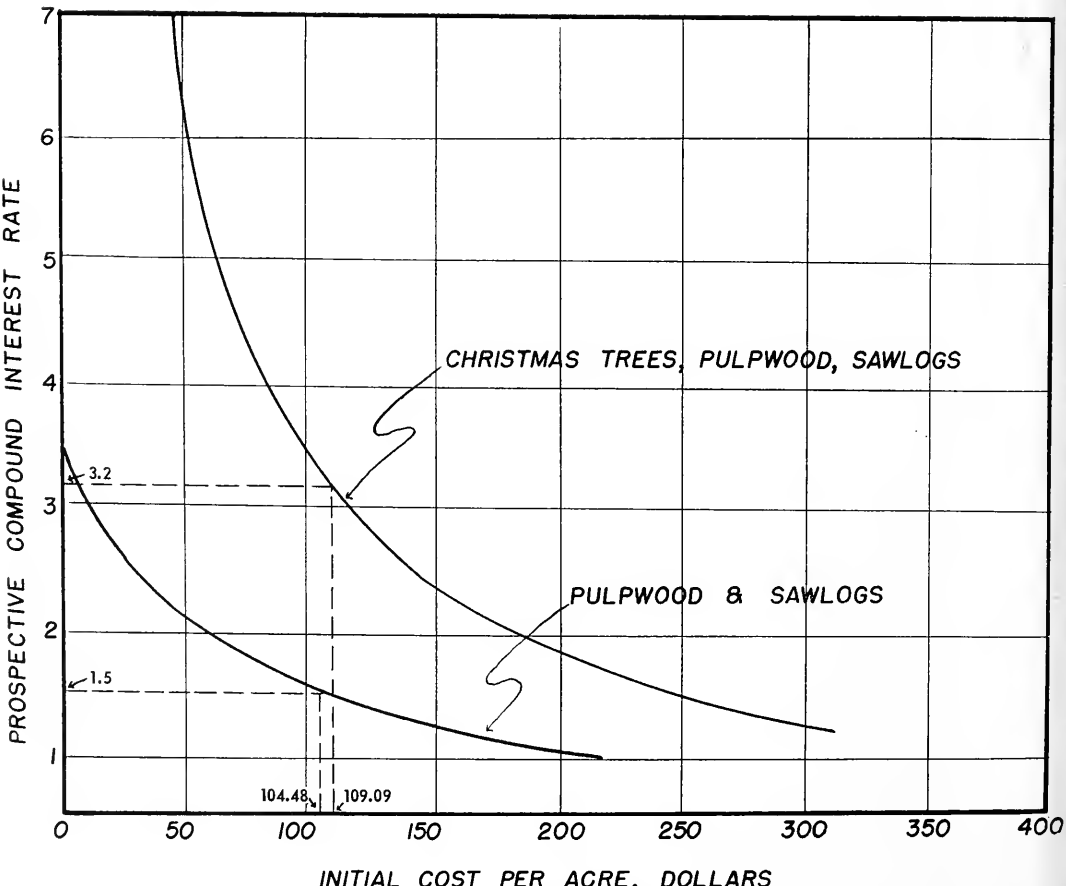


FIGURE 1. Expected compound interest rates possible from pulpwood and sawlog production (Case 1) and Christmas tree, pulpwood and sawlog production (Case 2). The initial cost per acre includes the total cost for soil value, brush-control method, planting labor, and planting stock.

The prospective rate of interest from this analysis is shown in Figure 1 (pulpwood and sawlog curve).

Example. From Figure 1 it can be seen that, if brushland is obtained for $20 per acre for a pulpwood and sawlog rotation, and basal spraying is to be used for brush control, the initial costs per acre (see Table 1, Columns A and B) are:

Soil value	$20.00
Basal spraying	40.96
Planting labor	29.00
Planting stock	14.52
Initial cost per acre	$104.48

Entering this value on the horizontal axis and reading the prospective rate of interest from the vertical axis, a rate of compound interest of 1.5 per cent is obtained.

Case 2. Christmas trees, pulpwood, and sawlogs. Five hundred Christmas trees are harvested from the stand eight years after the plantation is established. The remaining trees are left for pulpwood and sawlogs. In this case, the cleaning cost for the first rotation may be omitted, since effective control is afforded by the two annual mowings, which must be continued until the Christmas trees are harvested.

Conditions

Area	One acre
Crop production period	Repeated production on a 70-year rotation

Costs

Mowings (2 annually for the first 8 years)	$ 20.00/year
Pruning (annually from the third through the eighth year)	20.00/year
Protection, taxes and administration	10.00/year
Cleaning in later rotations	22.00/year

Returns

Christmas trees (500 @ $1/tree)	500.00
Thinning, age 30 (6 cords pulpwood @ $2/cord)	12.00
Thinning, age 40 (6 cords pulpwood @ $2/cord)	12.00
Thinning, age 55 (4 cords pulpwood @ $2/cord) and 3,000 bd. ft. sawlogs @ $18/M)	62.00
Harvest cutting, age 70 (12,000 bd. ft. sawlogs @ $18/M)	216.00

The prospective rate of interest from this analysis is shown in Figure 1 (Christmas trees, pulpwood, sawlogs).

Example. If brushland is obtained for $20 per acre, and bulldozing is used to clear the site, the initial costs per acre (see Table 1, Columns A and B) are:

Soil value	$20.00
Bulldozing	55.57
Planting labor	19.00
Planting stock	14.52
Initial cost per acre	$109.09

Entering this value on the horizontal axis and reading the prospective rate of compound interest from the vertical axis, a rate of 3.2 per cent is obtained.

Case 3. Christmas tree production alone. Because of the early large returns and short rotations, many persons originally interested in Cases 1 or 2 may be attracted into continuous Christmas tree production. If so, even larger returns are possible than through integration of Christmas tree production with pulpwood and saw logs. The production figures, based on a rotation of eight years, are as follows:

Conditions

Area	One acre
Crop production period	Repeated production on an 8-year rotation

Costs

Mowing (2 annually)	$ 20.00/year
Pruning (annually from the third through the eighth year)	20.00/year
Protection, taxes and administration	10.00/year

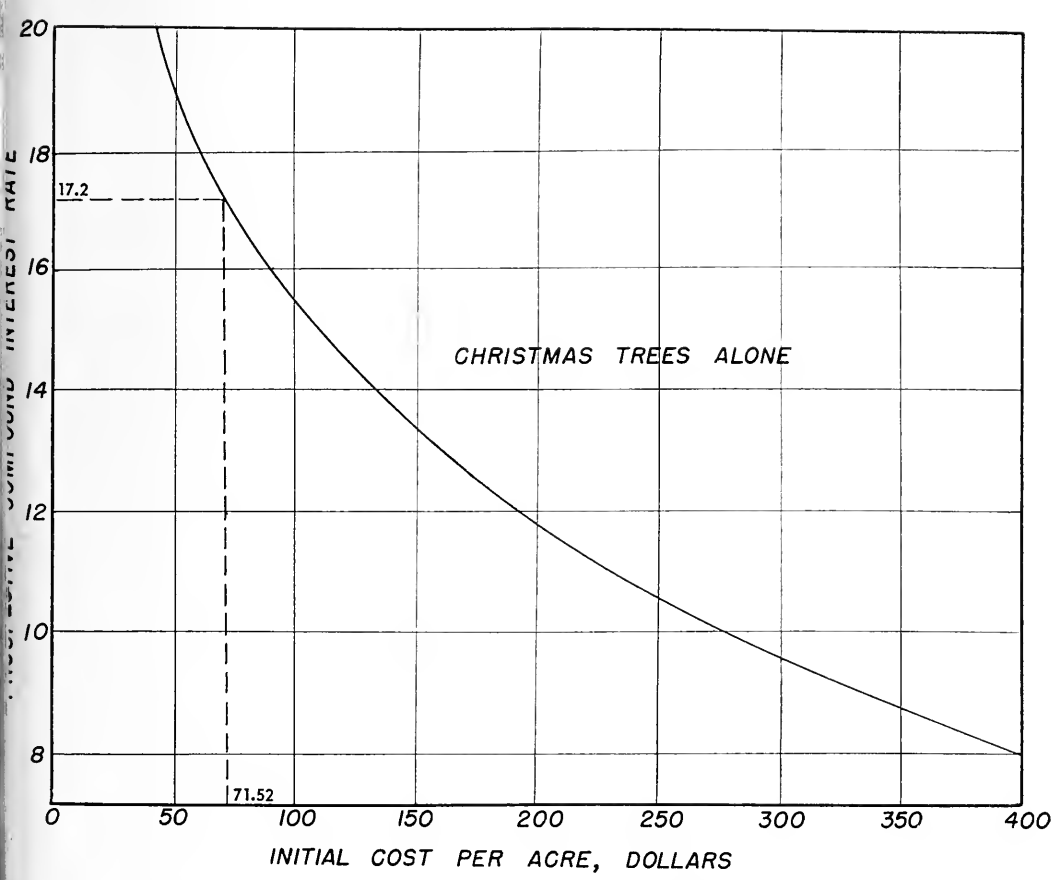
Returns

Christmas trees (847 @ $1/tree)	847.00

The results of this analysis, including yields from future rotations, are shown in Figure 2 (Christmas trees alone).

Example. If brushland is obtained for $20 per acre and foliage spraying is used to clear the site, the initial costs per acre (see Table 1, Columns A and B) are:

Soil value	$20.00
Foliage spraying	21.00
Planting labor	16.00
Planting stock	14.52
Initial cost per acre	$71.52



IGURE 2. Expected compound interest rates possible from Christmas tree roduction (Case 3). The initial cost per acre includes the total cost for soil alue, brush-control method, planting labor, and planting stock.

ntering this value on the horizontal axis and reading the prospective ıte of interest from the vertical axis, a rate of compound interest of 7.2 per cent is obtained.

In connection with Case 3, the production of successive Christmas ee crops, a word of caution is warranted. Validly computed from esent-day costs and incomes, it indicates a very high prospective rate return. Such a rate is likely to, and in fact already has induced other oducers to enter the business. Since it is not probable that the Christas tree market is capable of indefinite expansion, increased produc-ɔn might well flood the market and result in a lowered sale price as owers seek to sell their products. This will lower the rate of return r future growers, and it seems inevitable that some such downward justment will take place. The landowner who devotes all his efforts to e production of Christmas trees will have to be particularly alert in ging the probable market demand and supply if he wishes to avoid vere disappointment at some future date.

Conclusions

Over a five-year period 31 half-acre plots were established on com pletely brush-covered land. Eight widely advocated methods of brus control were tested prior to planting these plots with pine or hardwoo seedlings.

When costs, survival, and growth are considered, foliage sprayin bulldozing, and the brush-cutting saw appear to be the most effectiv methods of preparing brush-covered lands for coniferous planting These methods, when correctly applied, open up the site adequately fo the shade intolerant conifers. Foliage spraying is most effective wher brush is less than 10 feet in height; the brush cutter is satisfactory whe few trees exceed 20 feet in height or 2 inches in diameter; and the bul dozer is needed where larger vegetation is encountered.

For hardwood plantings a combination of frilling and basal spra ing controls brush and woody growth at a relatively low cost, and pr vides a suitable environment for hardwood seedlings to become estal lished and grow rapidly.

Because of the high cost of hardwood control and planting, dete mined through this study, it appears economically impractical to co vert brush-covered lands purely for pulpwood and sawtimber productio Costs vary with the extent of the brush cover, hardwood control metho employed, and species planted, but all costs are far in excess of thos currently considered feasible for plantation establishment. These cos should be borne in mind by foresters acquiring land for pulpwood an sawtimber production. Recently abandoned fields, where brush has n yet invaded, must be purchased—not brush-covered lands—since th former can be planted at far more reasonable costs and will presen fewer management problems.

When products other than pulpwood and sawlogs are to be pr duced, the capital needed for brush control and seedling establishmen can be a sound investment. Production of Christmas trees or orn mentals involves a rapid turnover of invested funds. Since interest o costs will be accumulated over a much shorter period, a greater initi expenditure is allowable. Furthermore, Christmas trees or ornamenta may be harvested in conjunction with the first pulpwood and sawlo rotation, thus providing the needed early income to offset high sit preparation and planting costs.

Finally, where aesthetic factors are a serious consideration, larg expenditures can be justified for this reason alone to replace brush wit plantations.